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# BRAKE APPLICATION SYSTEM COMPRISING AN ELECTRICALLY ACTUATED WEAR ADJUSTER

Specification

Prior Art

[0001] The invention is based on a brake application system for vehicles, particularly for rail vehicles, containing a wear adjuster constructed as a brake rod or thrust rod actuator and having a screw drive which has a threaded spindle and a nut to be screwed to the latter, as the screw parts, according to the type of Claim 1.

[0002] A brake application system of this type is known from European Patent Document EP 0 699 846 A2, which describes a wear adjuster for rail vehicle brakes in the form of brake rod and thrust rod actuators which, in the case of a brake pad and brake disc wear respectively, keep the brake pad play constant. This takes place by a change of length of the screw drive, in the case of thrust rod actuators, an increasing actuator length causing a reduction of the brake pad play. The drive of the known screw drive takes place mechanically by way of a brake linkage with a thrust rod which, in the event of an excess stroke of a brake actuator constructed as a pneumatic cylinder - piston driving gear, is operated by a rocker lever.

[0003] The present invention is based on the object of further developing a brake application system of the initially mentioned type such that it requires less space and a more precise adjusting of the brake pad play is permitted.

[0004] According to the invention, this object is achieved in that at least one of the screw parts is electrically actuated for the wear adjustment.

Advantages of the Invention

[0005] As a result of the direct electric control of at least one of the screw parts of the screw drive for the wear adjustment, the known brake linkage can be eliminated. Since the electric drive unit has a smaller size than the brake linkage, space and weight are saved. Furthermore, as a result of the electric control of the screw drive a more precise adjusting becomes possible in comparison to a mechanical operation.

[0006] As a result of the measures indicated in the subclaims, further developments and improvements of the invention indicated in Claim 1 can be achieved.

[0007] According to a preferred embodiment of the invention, an electric drive unit is provided which consists of an electric motor with a gearing arranged on the output side, the gearing output being rotationally coupled with an electrically actuated screw part. The

electric motor preferably is a d.c. motor; the gearing contains a planetary gear axially adjoining the electric motor as well as one or more gearwheel stages arranged behind this planetary gearing.

[0008] Particularly preferable measures provide a clutch by which the electrically actuated screw part, in the event of the presence of an axial force originating from a braking, can be non-rotatably coupled with a non-rotatable part, for example, a housing, and otherwise can be uncoupled therefrom. As a result, the screw part loaded by way of the caliper levers of the brake application system by the braking power is supported on the housing and not on the electric drive unit, which can therefore be dimensioned to be smaller, which also contributes to a reduction of the size.

[0009] According to a further development, a sliding clutch is arranged between the electric drive unit and the electrically actuated screw part, which sliding clutch is constructed to be sliding through when stop positions are reached and is otherwise coupling. One stop position is formed, for example, by the application of the brake pads on the brake disc, and another stop position is formed by a screw connection end position in which the electrically actuated screw part is screwed to the stop into the other screw part or vice-versa. In the latter case, the electrically actuated screw part would be rotated along with the other screw part, and the rotating movement would be undesirably transmitted to the electric drive unit. The sliding clutch therefore protects the electric drive unit from impacts when the stop positions are reached in that it slides through in order to permit the motor to softly and gradually conclude its rotating movement and uncouples it from torques introduced by way of other components. The sliding clutch is preferably connected between the coupling and the electric drive unit.

[00010] In a particularly preferable manner, the other screw part of the screw drive can be rotatorily driven for the emergency and/or auxiliary release of the brake. The screw drive is then used in the sense of a combination of functions in a constructional unit, on the one hand, for the wear adjustment and, on the other hand, for the emergency and/or auxiliary release of the brake, whereby space and weight can again be saved.

Drawings

[00011] Embodiments of the invention are illustrated in the drawing and will be explained in detail in the following description.

[00012] Figure 1 is a longitudinal sectional view of a thrust rod actuator of a brake application system of a rail vehicle according to a preferred embodiment in a position moved in to the minimal length;

[00013] Figure 2 is a longitudinal sectional view of a thrust rod actuator according to another embodiment in a position moved out to the maximal length;

[00014] Figure 3 is a view of the thrust rod actuator of Figure 2 in a position moved in to a minimal length.

Description of the Embodiments

[00015] For reasons of scale, Figure 1 shows only a wear adjuster 1 in the form of a thrust rod actuator as part of an electromechanically, pneumatically or hydraulically operable brake application system which, according to a preferred embodiment, is intended for an urban railway or a subway, which thrust rod actuator, in the position illustrated in Figure 1, is in a position moved in to the minimal length, whereby the brake pads take up a maximal distance from the brake disc.

[00016] The thrust rod actuator 1 contains a screw drive 2 which, as the screw parts, has a threaded spindle 4 and a nut 8 which can be screwed onto this threaded spindle 4 by means of a trapezoidal thread 6 and is constructed as a tube-type part. The trapezoidal thread 6 preferably is not self-locking. For the wear adjustment, the thrust rod actuator 1 is designed to be operated electrically, for which an electric drive unit 10 is provided which consists of an electric motor 12 with a gearing 14 connected behind it, whose gearing output is preferably rotationally coupled with the threaded spindle 4. As an alternative, the nut 8 or the threaded spindle 4 and the nut 8 can also be designed to be electrically actuated for adjusting the wear.

[00017] The electric motor is formed, for example, by a d.c. motor 12, and the gearing 14 is formed by a planetary gearing 16 axially adjoining the d.c. motor 12 as well as by a gearwheel stage 18 connected to the output side of the planetary gearing 16. The d.c. motor 12, the planetary gearing 16 and the gear wheel stage 18 are arranged parallel and at a radial distance from the center axis 20 of the screw drive 2 and are housed in a drive housing 22 flanged to a housing part 24, on the left in Figure 1, of the thrust rod actuator 1, to which thrust rod actuator 1 a left caliper lever of a caliper of the brake application system is linked, which caliper lever is not shown. A housing part 26 which, viewed in the axial direction of the screw drive 2, is on the right is situated opposite the left housing part 24 and the right caliper lever of the caliper is linked to this right housing part 26. Such a caliper is sufficiently known and is described, for example, in European Patent Document EP 0 699 846 A2, to whose entire disclosure content reference is made here. The left housing part 24 and the right housing part 26 of the thrust rod actuator 1 are held on one another at a spacing variable by means of the screw drive 2 in that, by extending

the screw drive 2 or the thrust rod actuator 1, a wear adjustment can take place and the pad play between the brake pads and the brake disc, which enlarges with time, can be reduced again and can be held at a constant value.

[00018] The gearing-output-side gearwheel 28 of the gearwheel stage 18 meshes with a screw-side gearwheel 30 which, by means of a deep-groove ball bearing 32, is coaxially rotatably disposed on a cylindrical projection 34 of a conical sleeve 36. By means of a sliding clutch 38 arranged on the side of the screw-side gearwheel 30 pointing to the right housing part 26, the electric drive unit 10 is coupled with the conical sleeve 36. The sliding clutch 38 contains balls 40, which are pretensioned by a defined spring pressure in grooves constructed on the face of the screw-side gearwheel 30 and which are guided in bores 42 of a ring 44 non-rotatably held on the cylindrical projection 34 of the conical sleeve 36. At torques greater than a defined slipping moment, the form closure generated by the balls 40 pressed into the grooves is overcome and the clutch 38 slides through, whereby the electric drive unit 10 is uncoupled from the threaded spindle 4. By the appropriate selection of the spring parameters and of the ball - groove geometry, the slipping moment can be adapted to the momentarily existing requirements. In the present case, the clutch 38 slides through when the brake application system reaches stop positions, such as the position in which the brake pads come to rest on the brake disc or the position in which the thrust rod actuator 1 is shortened to the minimal length and the threaded spindle 4 is completely screwed into the nut 8.

[00019] The driving torque transmitted by means of the sliding clutch 38 to the ring 44 is introduced into the conical sleeve 36, on whose bottom a pin-shaped projection 46 is present whose radially outer surface forms a bearing surface of a slide bearing 48, which bearing surface is slidably and rotatably disposed in a housing-side bearing surface assigned to it. The slide bearing 48 is used as a bearing point of the threaded spindle 4, which bearing point is on the left side in Figure 1. The threaded spindle 4, in turn, is screwed by means of an end-side threaded pin 50 into an internal thread existing in the projection 46 of the conical sleeve 36 and is held there in a non-rotatable manner. As a result, the conical sleeve 36 can transmit the driving torque introduced by way of the sliding clutch 38 to the threaded spindle 4.

[00020] A cone clutch 52 containing at least two conical surfaces 56, 58, which can be stopped by mutual friction against one another and are arranged in an oblique manner viewed in the axial direction, is arranged in front of the electric drive unit 10, one of the conical surfaces 56 being constructed on the left housing part 24 and the other conical

surface 58 being constructed on the conical sleeve 36 screwed to the threaded spindle 4. When the threaded spindle 4 is axially loaded, the two conical surfaces 56, 58 are pressed against one another in the direction of the conical narrowing, whereby the respectively taken-up rotating position of the threaded spindle 4 is fixed by frictional engagement or adherence and the axial load is supported by the left housing part 24. In particular, a transmission of the axial load as a torque to the electric drive unit 10 is prevented. If, in contrast, no axial load is present, the cone clutch 52 is in the released state and the conical sleeve 36, together with the threaded spindle 4, can rotate freely with respect to the left housing part 24.

**[00021]** The tube-type nut 8 projects into a stepped passage opening 60 of the right housing part 26 and is rotatably disposed there by means of a deep-groove ball bearing 62 but is axially displaceably disposed with respect to its inner race. A sleeve 66 is non-rotatably and axially fixedly held in the end of the nut 8 which points away from the left housing part 24 and, by means of its outer circumference, rests slidingly on a seal 64 received in the passage opening 60 of the right housing part 26, the end of the sleeve 66 projecting out of the passage opening 60 being equipped with an application surface 68 for a screwing tool. In addition, by means of a sliding clutch 70, the nut 8 is coupled with a coaxial free-wheel sleeve 72 of a lockable free wheel 74 which, on the one hand, is axially displaceably held on the nut 8 and, on the other hand, is supported by way of a thrust bearing 76 preferably constructed as an axial needle bearing against a radial wall 78 of the right housing part 26. The nut 8 is therefore disposed in a thrust bearing.

**[00022]** The sliding clutch 70 is preferably formed by two conical gearings 80, 82 meshing with one another in the axial direction. One conical gearing 80 is constructed on a radially outer ring collar of the end of the nut 8 projecting into the right housing part 26, and the other conical gearing 82 is constructed on the radially inner circumferential surface of the free-wheel sleeve 72.

**[00023]** By means of a coil spring 86 supported at one end on the deep-groove ball bearing 62 and at the other end on an outer step 84 of the nut 8, the nut 8 is pretensioned against the free-wheel sleeve 72, so that the two conical gearings 80, 82 are in a mutual engagement. When a slipping moment is exceeded, the two conical gearings 80, 82 are disengaged while the nut 8 is axially displaced in the direction of the left housing part 24, whereby the nut 8 can rotate with respect to the free-wheel sleeve 72. The slipping moment of the sliding clutch 70 can be adapted by the suitable selection of the spring parameters and of the conical gearings 80, 82.

[00024] In the right housing part 26, a rotary drive 88 is accommodated for the emergency release and/or the auxiliary release of the brake application system, "emergency release" being a braking power reduction of the brake application system acted upon by braking power, for example, in the event of a failure of the brake actuator, and "auxiliary release" being a release of the brake not acted upon by braking power for maintenance work, for example, for changing the brake pads. In the present case, the rotary drive 88 is manually operated; that is, a turning tool is applied to one of two application surfaces 92 constructed on the end side on a shaft 90 rotatably accommodated in the right housing part 26 parallel to the center axis 20 of the screw drive 2, in order to cause the shaft 90 to rotate. As an alternative, the rotary drive 88 can also be designed to be remotely or electrically actuated by way of a Bowden cable.

[00025] The preferably manually caused rotation of the shaft 90 is transmitted by way of a gearwheel 94 shaped onto to it between the two application surfaces 92 and arranged within the right housing part 26 to a toothed sleeve 96 which meshes with the gearwheel 94 and is coaxial with the screw drive 2, which toothed sleeve 96 is rotatably accommodated in the right housing part 26 and is radially spaced by an annulus 102 with respect to a housing surface 100 which is flush with the radially outer circumferential surface 98 of the free-wheel sleeve 72 and axially adjoins the circumferential surface 98 of the free-wheel sleeve 72. A wrap spring 104 which is coaxial with respect to the center axis 20 of the screw drive 2 and has two pin-type ends 106, 108 bent away oppositely in the radial direction is accommodated in the annulus 102, one end 106 being formlockingly held in a radial passage bore of the toothed sleeve 96, and the other end 108 being formlockingly held in a radial passage bore of the free-wheel sleeve 72.

[00026] The toothed sleeve 96, the wrap spring 104, the free-wheel sleeve 72 and the housing surface 100 together form a lockable free wheel as a wrap spring free wheel 74, which couples the rotary drive 88 with the nut 8. More precisely, the wrap spring free wheel 74 is, on the one hand, constructed for rotating the nut 8 by means of the rotary drive 88 in a direction against the wear adjustment and, on the other hand, for locking this rotation when the rotation of the nut 8 is not caused by the rotary drive 88. The above-described sliding clutch 70 is arranged between the nut 8 and the wrap spring free wheel 74.

[00027] In the second embodiment of a thrust rod actuator 1 according to Figures 2 and 3, the parts which are identical to those in the preceding embodiment and have the same effect are marked by the same reference numbers.

[00028] In contrast to the above-described embodiment, the rotary drive 88 is formed by an additional electric drive unit 112 consisting of an electric motor preferably constructed as a d.c. motor 114, of a planetary gearing 116 as well as of a gearwheel stage 118, so that the two electric drive units 10, 112 preferably have an identical construction. As described above, the transmission-output-side gearwheel 120 meshes with the toothed sleeve 96, which, in turn, is coupled with the nut 8 by means of the wrap spring free wheel 74.

[00029] Relative to an imagined point of intersection of the center axis 20 of the screw drive 2 and an imagined vertical center line of the thrust rod actuator 1, the two electric drive units 10, 112 are arranged essentially point-symmetrically with respect to one another, in which case they point toward one another starting from the end of the threaded spindle 4 or of the nut 8. More precisely, the drive unit 10 for the wear adjustment projects essentially from the drive-side end of the threaded spindle 4 in the direction of the drive unit 112 for the emergency and auxiliary release, and the latter projects essentially from the drive-side end of the nut 8 in the direction of the drive unit 10 for the wear adjustment. As in the above-described embodiment, both drive units 10, 112 actuate a single screw drive 2 for the combined wear adjustment and emergency or auxiliary release. The right and the left housing part 24, 26 each consists of housing sections 122, 124 which are essentially symmetrical relative to the center axis 20 of the screw drive 2. The drive unit 10, 112 is in each case accommodated in one housing section 122, and one final position sensor 126 respectively is accommodated in the housing section 124 arranged on the other side of the center axis 20, which final position sensor 126 is situated opposite a face-side surface 128 of the drive housing 22 of the respectively other electric drive unit 10, 112. The final position sensors are preferably constructed in the form of mechanical final position switches 126, which are each actuated by the application of the face-side surface 128 of the drive housing 22 of the opposite drive unit 10, 112 and supply a signal for reaching the position illustrated in Figure 3, in which the thrust rod actuator 1 has moved in to the minimal length, to a control device, which is not shown for reasons of scale. At their ends pointing away from one another, the two housing sections 122, 124 of each housing part 24, 26 are in each case provided with one receiving device 132 for bolts, by which one caliper lever respectively of the caliper is linked to each housing part 24, 26. Furthermore, a wrap spring 138 of another wrap spring free wheel 140 is arranged on a cylindrical projection 134 of the planetary-gearing-side gearwheel 136 of the gearwheel stage 18 assigned to the drive unit 10 for the wear adjustment. This wrap spring free

wheel 140 blocks a rotation of the gearwheel 136 in the direction against the wear adjustment and permits it to run freely in the opposite rotating direction.

[00030] This means that the free wheel 140 between the drive unit 10 and the housing part 24 permits a rotation of the drive 10 only in the direction in which the thrust rod actuator 1 is lengthened.

[00031] Such a wrap spring free wheel 140 exists also in the case of the above-described embodiment but is not shown there. In the event of an effective control of the drive unit 10, for example, as a result of a software defect, or during a drive with a released brake, an unwanted shortening of the thrust rod actuator 1 is therefore not possible. Finally, the sliding clutch 70 arranged between the free wheel sleeve 72 and the nut 8, instead of being formed by two conical gearings, is formed by two contrate gearings 80, 82 meshing with one another as a result of spring pressure.

[00032] As a result of the described construction of the thrust rod actuator 1 according to the embodiments illustrated in Figure 1 and Figures 2 and 3, by means of a single screw drive 2, of which one screw part respectively is coupled with a separate drive unit, which is independent of the other drive unit, specifically, on the one hand, the threaded spindle 4 with one electric drive unit 10 and, on the other hand, the nut 8 with the manual rotary drive 88 or with the other electric drive unit 112, the brake pad wear can be corrected and the brake can be released for emergencies and/or in an auxiliary manner.

[00033] Based on this background, the method of operation of the thrust rod actuator 1 is as follows:

[00034] The wear adjustment, that is, the reduction of the brake pad play, which exists between the brake pads and the brake disc and which has become too large as a result of wear, takes place in the braking-power-free brake release position. For this purpose, the d.c. motor 12 of the electric drive unit 10 provided for the wear adjustment is controlled for a predetermined time and causes the threaded spindle 4 to rotate in one rotating direction by way of the sliding clutch 38 closed in the case of a driving torque which is smaller than the slipping moment, during which rotating movement the threaded spindle 4 is screwed out of the nut 8 and the thrust rod actuator 1 is thereby lengthened, which results in a reduction of the brake pad play. Figure 2 shows the thrust rod actuator 1 in a position in which it is moved out to its maximal length. Since the screw drive 2 is thereby loaded by only very low axial forces, the cone clutch 52 is in the released position, so that the threaded spindle 4 can rotate freely. The nut-side wrap spring free wheel 74 blocks a rotating-along of the nut 8, which is not secured against a rotation per se, because a

rotation of the nut 8 is transmitted by way of the sliding clutch 70 to the free-wheel sleeve 72 and from there to the wrap spring 104 which then pulls tight and establishes a frictionally engaged connection between the free-wheel sleeve 72 and the housing surface 100, whereby the nut 8 is non-rotatably supported on the right housing part 26.

**[00035]** During a braking, the bearing pressure force resulting from the braking power existing at the brake pads and transmitted by way of the hinged caliper levers of the caliper to the thrust rod actuator 1 and acting there in the axial direction could not be supported on the screw drive 2 because the trapezoidal thread 6 between the threaded spindle 4 and the nut 8 does not have a self-locking construction. As a result, the thrust rod actuator 1 would be shortened under the influence of the axial pressure force and thus an undesirable loss of braking power would be caused. However, the cone clutch 52 closes under the effect of the axial load by the pressing-together of the mutually assigned conical surfaces 56, 58 in a frictionally engaged manner and establishes a non-rotatable connection between the threaded spindle 4 and the left housing part 24. On the other hand, the nut-side sliding clutch 70 constructed as a conical gearing 80, 82 (Figure 1) or as a contrate gearing 80, 82 (Figure 2, Figure 3) remains closed under the axial load and transmits the moment of reaction to the wrap spring 104 which then pulls tight and supports the moment of reaction at the right housing part 26. As a result, no shortening of the thrust rod actuator 1 and thus no unintended loss of braking power can occur during a braking operation.

**[00036]** If a fault occurs, in the case of a brake actuator, which generates the braking power of the brake application system, or in its control, which has the result that the brake actuator can no longer release the brake acted upon by the braking power, this brake has to be subjected to an emergency release. For the emergency release of the brake, the shaft 90 of the rotary drive 88 (Figure 1) is rotationally operated, for example, by the application of a screwing tool to one of the application surfaces or by a Bowden cable or the electric drive unit 112 is controlled for the emergency release and/or auxiliary release from an engineers cab of the urban railroad or subway controlled, specifically in a rotating direction in which the wrap spring 104 is expanded and, as a result, the previously existing frictional engagement between the free-wheel sleeve 72 and the housing surface 100 is eliminated, whereby the nut 8 has a free run in this rotating direction. The wrap spring 104 can therefore transmit the rotating movement introduced into it by way of the toothed sleeve 96 to the free-wheel sleeve 72, by which the rotation is transmitted to the now freely running nut 8 by way of the closed sliding clutch 70. As a result, the thrust rod

actuator 1 is shortened and the braking power is reduced. The thrust rod actuator 1 can thereby be shortened to the minimal length illustrated in Figure 1 and 3 in which the nut 8 on the face side comes in contact with the bottom of the conical sleeve 36 and the final position switches 126 are actuated.

**[00037]** If, for maintenance work, the brake is to be moved into a position in which the brake pads are at a maximal distance from the brake disc, for example, for exchanging the brake pads, the release of the brake can also take place by way of rotatory drive 88 (Figure 1) or by the electric drive unit 112 for the emergency and/or auxiliary release (Figure 2, Figure 3) in the manner described above (auxiliary release). Since, however, the torque is limited which can be transmitted by means of the nut-side wrap spring 104 expanded by the driving torque and subjected to a bending stress, in the cases in which the screw drive 2 is stiff, for example, because of icing, the nut 8 is rotated directly for shortening the thrust rod actuator 1. This takes place in the braking-power-free state by applying a screwing tool to the application surface 68 of the sleeve 66 non-rotatably connected with the nut 8, in which case the latter is manually rotated in a direction in which the thrust rod actuator 1 is shortened to the minimal length illustrated in Figure 1 and Figure 3. The torque must be so large that the sliding clutch 70 arranged between the free-wheel sleeve 72 and the nut 8 can slip, while the wrap spring 104 of the wrap spring free wheel 74 blocks the free-wheel sleeve 72 in this direction. In this case, the nut 8 is displaced so far away from the free-wheel sleeve 72 in the axial direction that the two conical gearings 80, 82 (Figure 1) or the two contrate gearings 80, 82 (Figure 2, Figure 3) are disengaged.

**[00038]** The invention is not limited to thrust rod actuators 1 of brake application systems but can also be used for brake rod adjusters.

[00039] List of Reference Numbers

| | |
|---|---|
| 1 | Thrust rod actuator |
| 2 | screw drive |
| 4 | threaded spindle |
| 6 | trapezoidal thread |
| 8 | nut |
| 10 | electric drive unit |
| 12 | electric motor |
| 14 | gearing |
| 16 | planetary gearing |
| 18 | gearwheel stage |
| 20 | center axis |
| 22 | drive housing |
| 24 | left housing part |
| 26 | right housing part |
| 28 | gearwheel |
| 30 | gearwheel |
| 32 | deep-groove ball bearing |
| 34 | cylindrical projection |
| 36 | conical sleeve |
| 38 | sliding clutch |
| 40 | balls |
| 42 | bores |
| 44 | ring |
| 46 | projection |
| 48 | slide bearing |
| 50 | threaded pin |
| 52 | cone clutch |
| 56 | conical surface |
| 58 | conical surface |
| 60 | passage opening |
| 62 | deep-groove ball bearing |
| 64 | seal |

| | |
|---|---|
| 66 | sleeve |
| 68 | application surface |
| 70 | sliding clutch |
| 72 | free-wheel sleeve |
| 74 | free wheel |
| 76 | axial bearing |
| 78 | wall |
| 80 | conical gearing |
| 82 | conical gearing |
| 84 | outer step |
| 86 | coil spring |
| 88 | rotary drive |
| 90 | shaft |
| 92 | application surfaces |
| 94 | gearwheel |
| 96 | toothed sleeve |
| 98 | circumferential surface |
| 100 | housing surface |
| 102 | annulus |
| 104 | wrap spring |
| 106 | end |
| 108 | end |
| 112 | electric drive unit |
| 114 | d.c. motor |
| 116 | planetary gearing |
| 118 | gearwheel stage |
| 120 | gearwheel |
| 122 | housing section |
| 124 | housing section |
| 126 | final position switch |
| 128 | surface |
| 132 | receiving device |
| 134 | projection |
| 136 | gearwheel |

| | |
|---|---|
| 138 | wrap spring |
| 140 | wrap spring free wheel |